SPECIAL OBSERVATIONS

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The profiler is one of the new special observation devices. Figure 1 shows the impact of various meteorological data types on "forecast lead time." A scale called "relative importance" is used to avoid advocating a particular sensor. Clearly, radar is most useful in the short, nowcast (out-to-one-hour) time frame. Satellites and surface observations are also most useful for short-range forecasts but have less impact on the longer range. The radiosonde network, on the other hand, only starts to be very important after about 6 hours and has greatest impact at lead times of 12 hours or more. It has even been suggested that forecasts of greater than 12 hours may be better than present short-range forecasts.

Many people speak of a data "gap". A data "valley" is seen in Figure 1, but is not a real gap. So why are we concerned? What do we need to do differently? I submit that we have been viewing this diagram incorrectly, and that, in fact, it is a three-dimensional diagram (Figure 2). Observations are of two fundamental types: 1) those which show atmospheric discontinuities, and 2) those which show basic fields in the atmosphere. It is the atmospheric discontinuities which are most important to one-hour forecasts. For example, radar detects an atmospheric discontinuity (e.g., a thunderstorm), whose position can be extrapolated for a short distance. The second type, the actual measurement of a basic field of wind, temperature, or humidity, is needed to do true forecasting for more than one hour.

We are attempting to correct these weaknesses with VAS and Doppler radar, but I submit that we still have a gap. I further suggest to you in the aviation community that this is a very important area for aviation forecasting. The importance of the two-to-eight-hour forecasts becomes evident when we try to define the critical weather that may be encountered during, for example, a flight from New York to Los Angeles.

Radiosonde vs. Profiler

Of course, radiosondes could be placed at much greater density all over the United States, and the frequency of the soundings could be increased to every couple of hours. This would, however, be extremely difficult to accomplish because of some of the characteristics of a radiosonde (Figure 3). First, it is difficult to obtain good temporal resolution. The temporal resolution of a radiosonde is only as fast as a man can blow up and release a balloon. Even this rate is limited because a second balloon cannot be launched until the first has burst and allowed the transmitter to fall to the ground. Temporal resolution is, therefore, limited regardless of how

IMPACT OF METEOROLOGICAL DATA TYPES

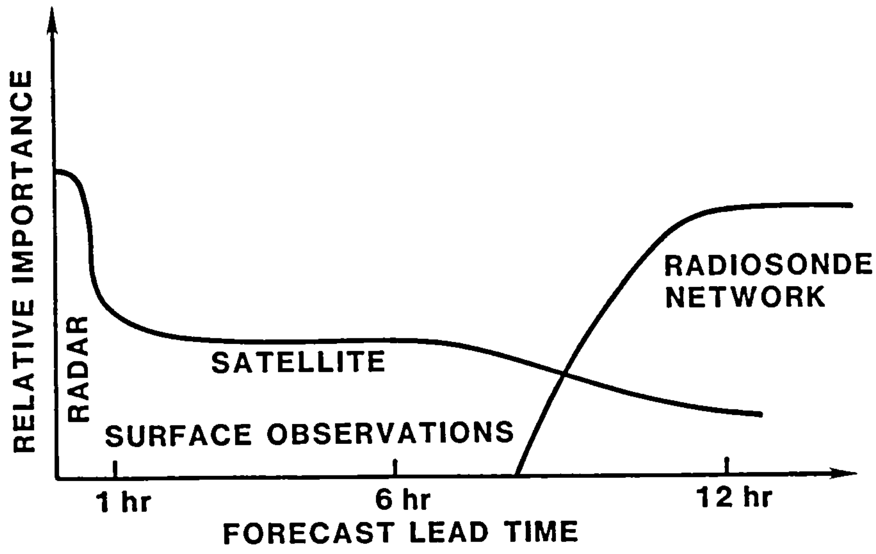


Figure 1. One perception of the impact of various instruments on forecast lead time.

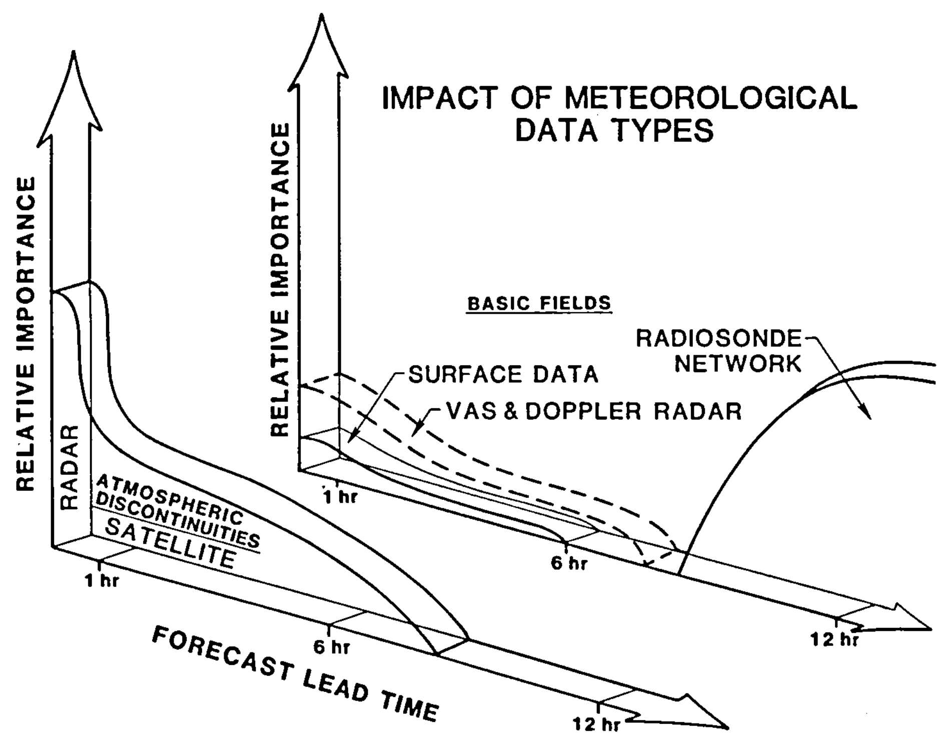


Figure 2. A different view of the impact of various instruments on forecast lead time.

- Accuracy - ?
- Reprentativeness - ?
- Temporal Resolution - as fast as a man can launch
- Height Limits ≈ 100mb
- Labor Intensive
- Reliability = Good
- Automation - Nearly Impossible
- Cost - $\$200^{oo}$-$\$300^{oo}$/Launch

Figure 3. Some of the characteristics of the radiosonde.

many radiosonde sites are provided. Second, it is nearly impossible to automate a balloon system. Therefore, it would seem preferable to find another solution. We believe it is the profiler.

The wind is measured by using clear-air Doppler radar principles. Two fixed beams, pointing 15 degrees to the north and 15 degrees to the east, sense the Doppler shift. The resulting wind vectors are then rotated to the horizontal and combined to give total wind. Figure 4 is a schematic of a 50 MHz wind profiler showing three beam positions (one vertical). The antenna for this system takes up an area of about 50 m on a side. Figure 5 is a photo of another version of the wind profiler (the 915 MHz system located near Denver, Colorado). Work is currently under way on a 405 MHz system which has a much smaller antenna. This smaller version could well be the forerunner of commercial systems.

Comparisons of the winds measured by a profiler with those from a radiosonde have been made many times over the past few years. We generally find that the profiler is better than the radiosonde. Figures 6 and 7 illustrate the wind measurement capabilities of the profiler. Figure 6 shows winds measured at NOAA's Platteville, Colorado, site early in 1985 when a winter storm was moving through Colorado. A range of 16 km is shown. Figure 6 shows the wind field that would have been measured by 12-hour radiosonde ascents. Figure 7 is the same wind field as measured by the profiler. The profiler is a very high temporal resolution system which operates automatically. You do not need to send up a balloon. During any 12-hour period the profiler can show mesoscale features that simply cannot be seen by using radiosondes. In Figure 7, for example, the profiler winds indicate a mesoscale low-pressure center that would have been missed by 12-hour radiosondes.

The radiosonde measures temperature and humidity as well as wind. Here the story of the profiler is not quite so bright. A profiler measures temperature and humidity by using passive radiometers. Figure 8 is a time/height plot of radiometer-derived and radiosonde-measured temperature profiles near Denver, Colorado. The dashed lines are from radiosonde-measured temperatures 12 hours apart. The smooth curves are the radiometer temperatures. Notice that the radiometer does not see sharp "kinks" in the temperature profile. However, it does show when the ground-based inversion broke up. Some meteorologists suggest that this smooth profile is adequate. Others point out that the ground-based and upper-level inversions are very important in predicting the onset of mesoscale convection. The Wave Propagation Laboratory is doing research on adding the kinks to the radiometric temperature profiles. On the positive side, the radiometric system is capable of very accurately measuring the height of pressure surfaces, one of the primary inputs to numerical weather prediction models.

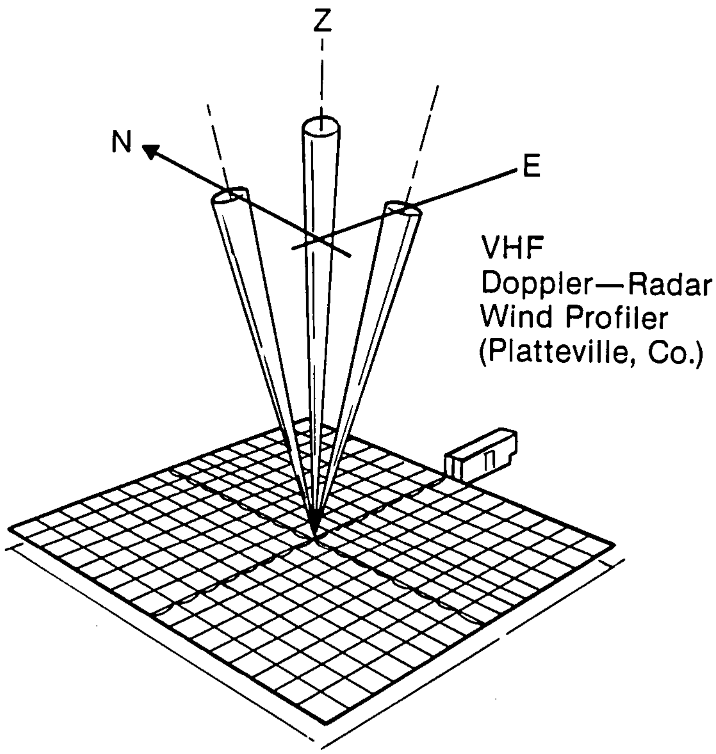


Figure 4. A schematic showing the 50 MHz antenna and fixed beam pattern. The inset shows the building that houses the radar and processing equipment.

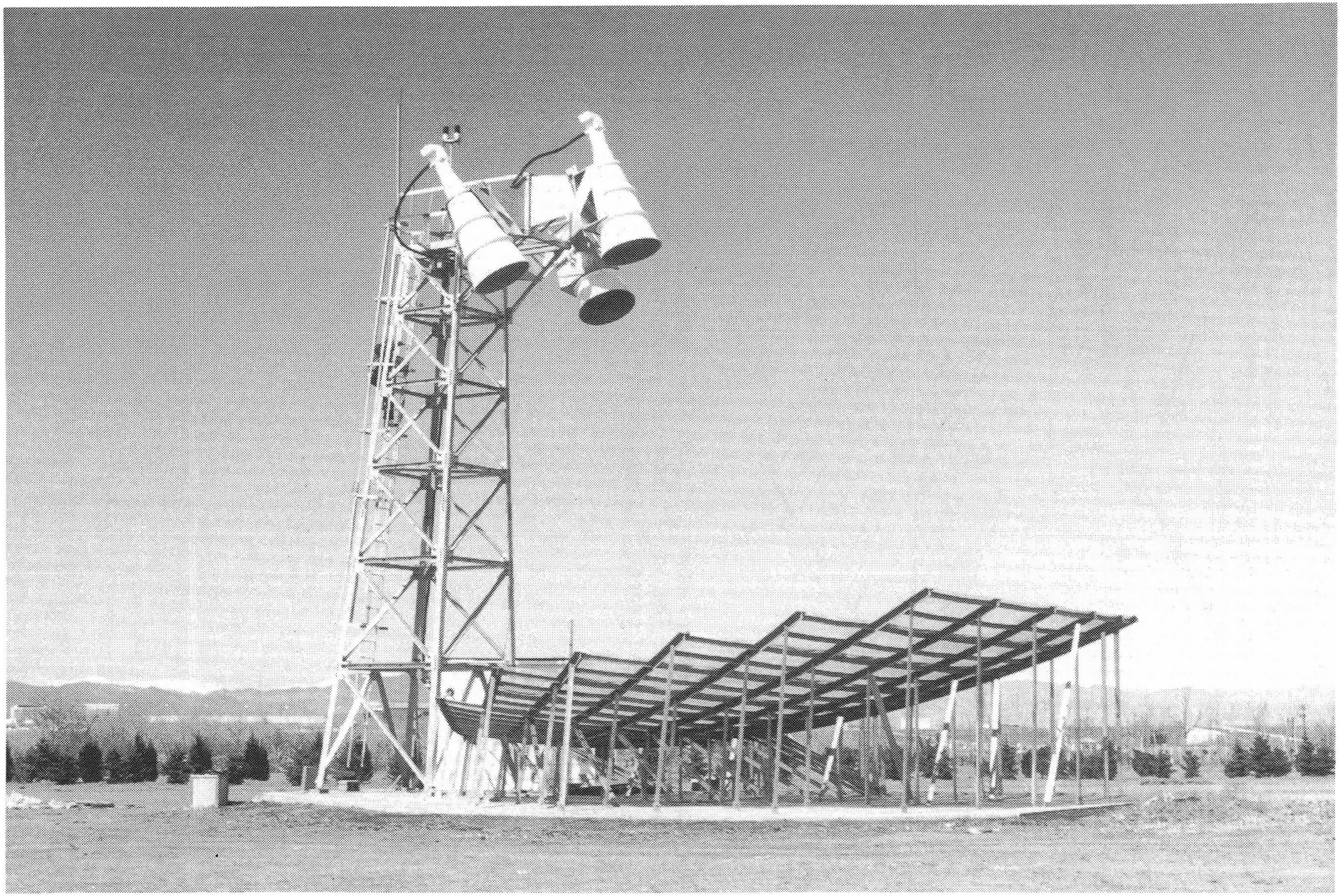


Figure 5. The 915 MHz wind profiler located at Stapleton Airport near Denver, Colorado.

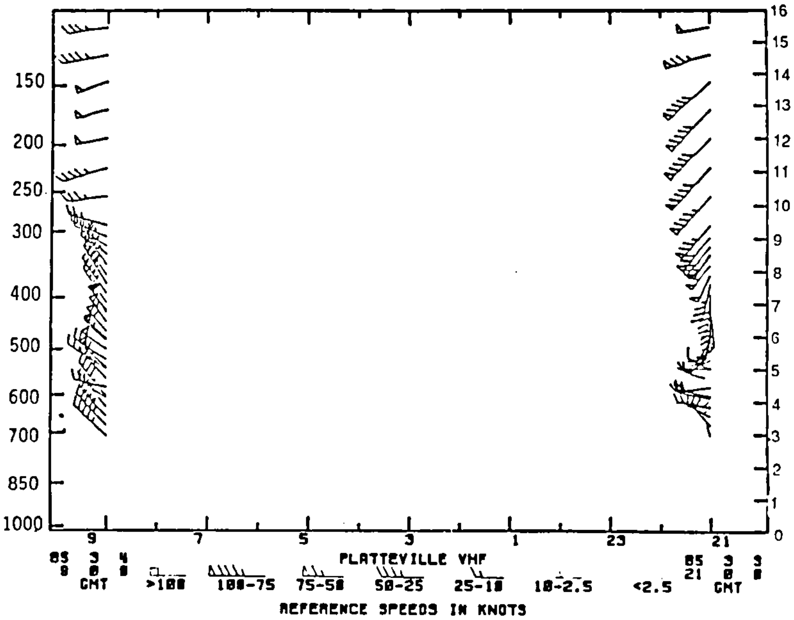


Figure 6. A time/height section of wind profiles. The left vertical scale is pressure height and the right vertical scale is in km above sea level. The wind barb values are given below the figure. Wind direction is represented by the direction of the wind arrow with north at the top of the figure. The two profiles represent the winds that would be measured by 12-hourly radiosonde ascents.

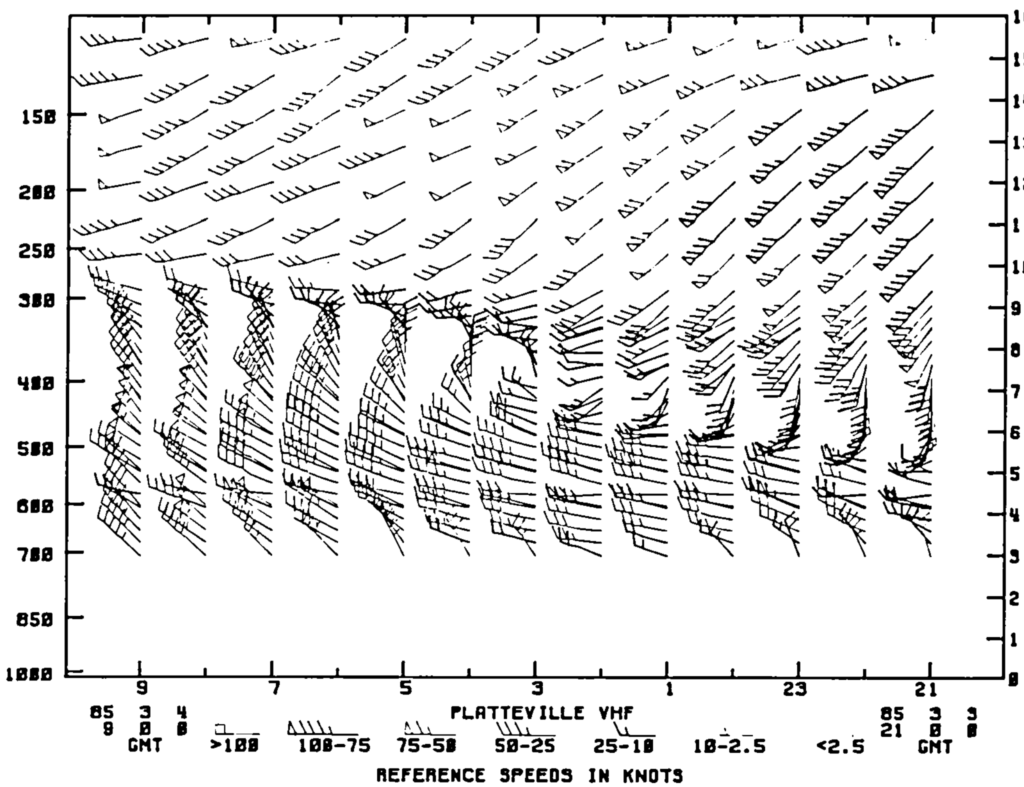


Figure 7. Same as Figure 6, only showing the number of wind profiles that would be provided by a profiler in the same 12-hour period. Note the mesoscale detail that is revealed by the higher temporal resolution.

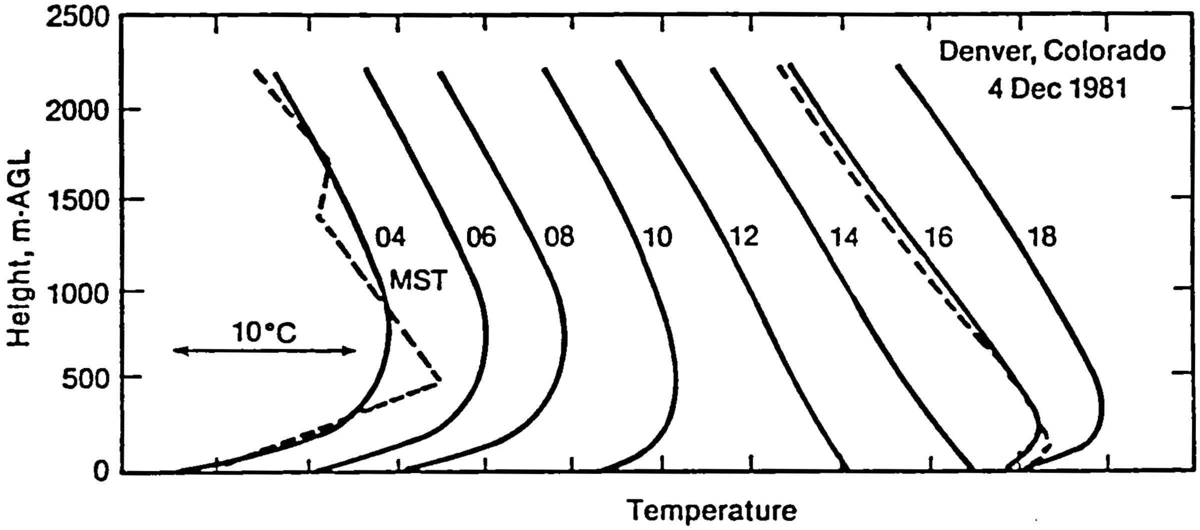


Figure 8. Time/height section of temperature profiles taken by a radiosonde (dashed lines) and a thermodynamic profiler (solid lines). The tic marks on the bottom represent one-hour intervals.

The wind profiler development is 95% complete. It is ready for implementation, and we are starting a program where that will occur. Temperature profiler development is probably only 75% complete. The remaining work is pictorially represented in Figure 9. The dashed lines suggest the sharp inversions that might be seen in a radiosonde trace. The solid lines represent the temperature profiles from a radiometer at various points in our projected research plan. First, we know that by simply combining data from ground-based and satellite radiometers, the height of the profile can be extended. This is an improvement over both the ground-based and the satellite temperature profiles. Second, the wind profiler can detect the height of inversion layers because the radar receives stronger signals from regions where temperature inversions are present. This information can then be added to the profile. Finally, we have shown through computer simulation that the relationship between the temperature and wind field can be used to improve the derived temperature profiles. The high-resolution winds from a network of profilers can be used to reproduce the temperature field and, in turn, to add the kinks in the radiometric temperature profile.

Wind profilers are to be installed in the central U. S. Figure 10 shows one of the proposed configurations for this network. The network will contain 30 to 35 profilers some operating at 405 MHz, others at 50 MHz. This network will be used to test the operational characteristics of the profiler system and to assess the optimum frequency and distribution of profilers in a network.

We are also looking at ways profilers might be used to support such operations as the Space Shuttle launch (Figure 11). This is a rather interesting special problem because, at present, the best wind profile available for launch support is taken three and one-half hours before the launch. With a profiler, winds could be measured right up to the time of launch. The Shuttle recovery problem is equally interesting. It is difficult to provide a four-hour forecast of whether there will be a thunderstorm over the end of the runway. Accurate high-resolution upper-air and surface measurements on and around the Florida peninsula would make the recovery forecast much easier.

Summary

If we are to improve our ability to forecast weather, we must have better high-resolution data sets. We must also recognize that these high-resolution observations are needed for research in order to develop understanding and forecasting techniques. The critical role of high-resolution measurements and their link to automation, training, and improved mesoscale services is depicted in Figure 12. There is one link on this diagram that we seem to overlook. We do wonderful research experiments that employ high-resolution instrumentation. We operate for two months, then remove the instruments and go away to develop new forecast techniques that

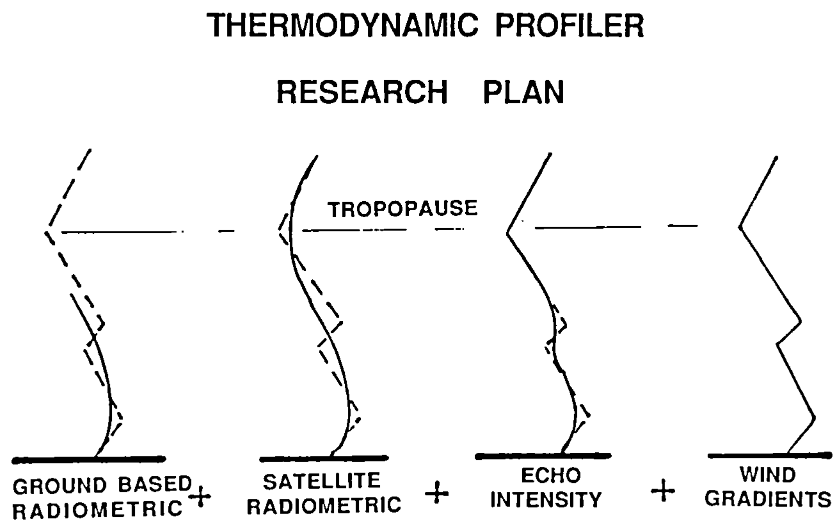
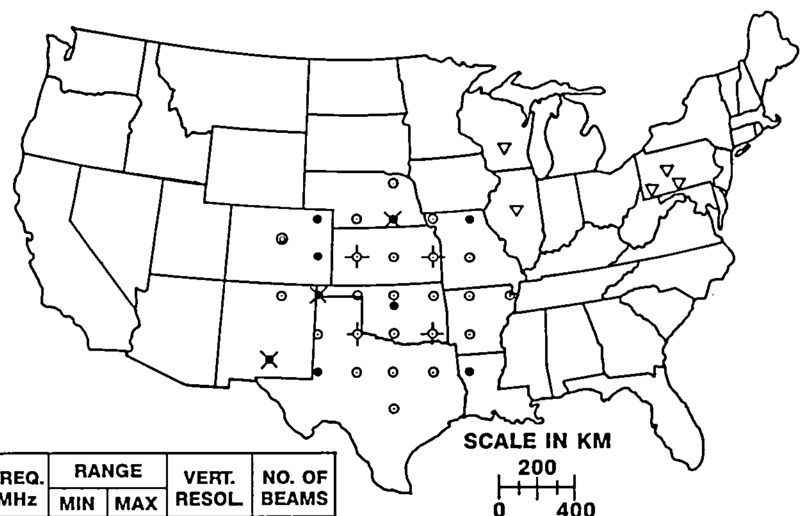


Figure 9. Schematic representation of the research steps required to improve the height resolution of the thermodynamic profiler. See text for fuller explanation.

A Proposed 1989 Wind Profiler Network



SYMBOL	FREQ. MHz	RANGE MIN	RANGE MAX	VERT. RESOL.	NO. OF BEAMS
●	50	1 km	15 km	LOW	2
⊙	405	.3 km	10 km	HIGH	3
-◇-	405	.3 km	10 km	HIGH	5
✖	225	.5 km	14 km	MED	3
o	915	.3 km	8 km	HIGH	3
▽	OTHER PROFILERS				

Figure 10. One of the proposed profiler network configurations.

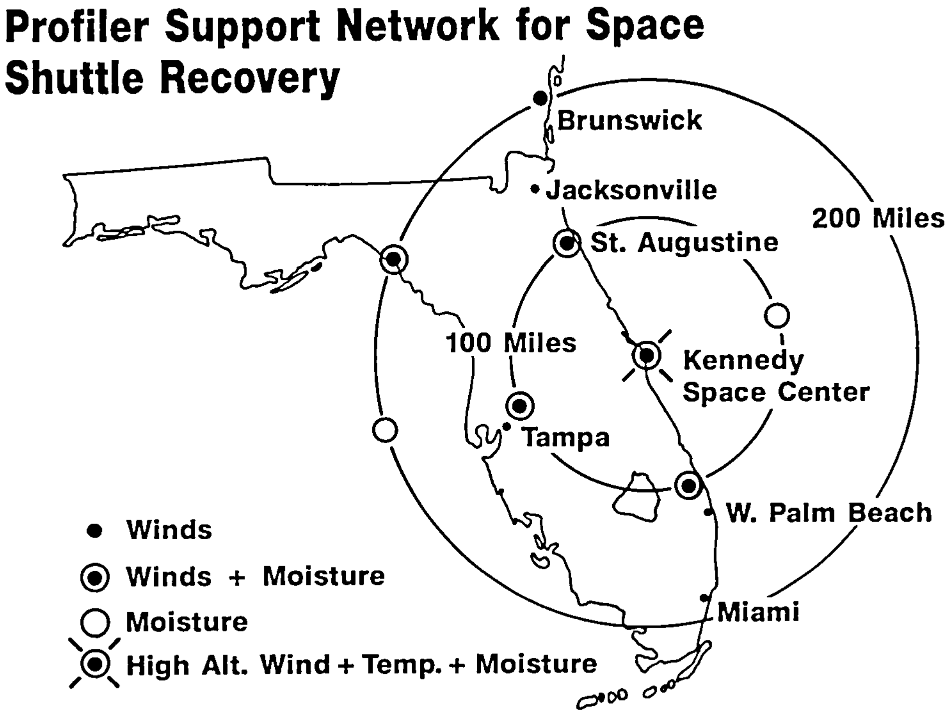


Figure 11. A proposed profiler network for supporting Space Shuttle launch and recovery operations at Kennedy Space Center.

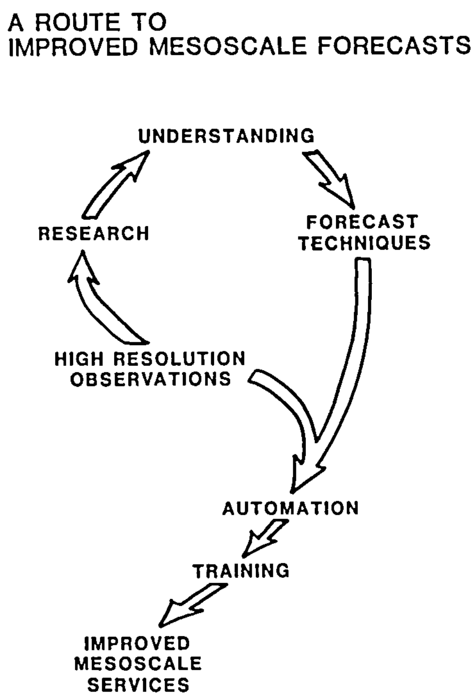


Figure 12. The route to improved forecasts and services.

are given to the operational forecaster to use. But we forget to leave the instruments in the field. How is the forecaster going to make a better mesoscale forecast unless he has available an equivalent set of high-resolution data?

We developed the radiosonde when we had aircraft like those shown on the left side of Figure 13. The right side shows the aircraft that we now have, and we are still using the radiosonde as our basic upper-air instrument. I believe it is time for a change.

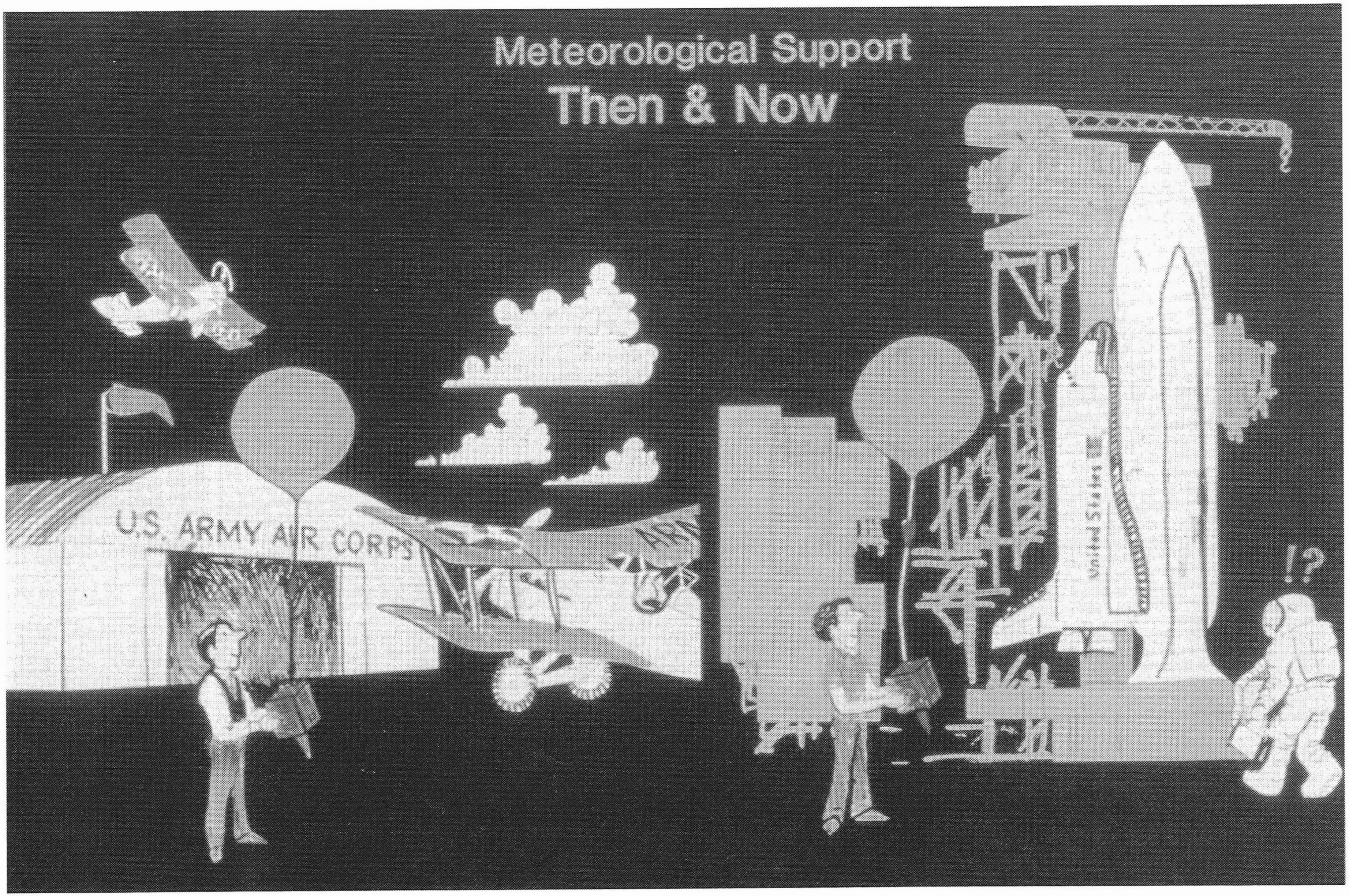


Figure 13. The progress in meteorological sensors compared to the progress in aeronautics.